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An Experimental Study on Homotransplantaion of Articular Cartilage

by

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The cartilage homografting are known to survive for long period, since the work by Prudden, Dupertius and other.[1,3,4,6,7,9,13,15,]

Experimental transplantation of articular cartilage has resulted in survival of the graft, but late degenerative changes occurred in the same grafts by weight-bearing.[3]

We tried to investigate behaviour and fate of the grafted cartilage plate using the scanning electron microscope and histological staining method.

Material and Method

(1) 50 adult rabbits weighing ca. 2.5 kg were used for this study.

(2) Round cartilage plate (ca. 4.0cm in diameter) was removed from the distal femur at the femoral condyle.

(3) The cartilage graft was transplanted on the defect produced at the distal femur as shown on Fig. 1 and was fixed with BIOBOND.* (EDH-Adhesive.)

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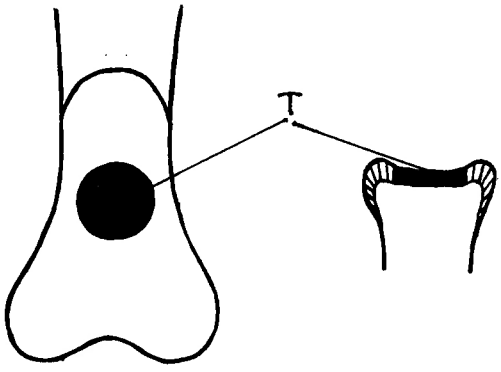

Fig. 1 Graft of articular cartilage located at facies patellaris femoris of femoral condyle, was fixed with Biobond. (T : transplant)

(4) The operated condyle was removed en bloc at 1, 4, 12, 24 weeks after transplantation and was studied with scanning electron microscope and histological methods (H&E., Alcian Blue, Masson Trichrome stainings).

Preparation of Specimen for S. E. M. Examination

Blocks of cartilage with subchondral bone were sawn from the joints, and washed in Ringer' solution to remove synovial fluid deposits and debris. The blocks were fixed for 24 hours in 10% neutral formalin, after being care-fully irrigated with physiological saline solution. Dehydration was accomplished in ascending strength of aceton, and was then allowed to dry in air. The surface of specimen was then coated with carbon and gold in a vacuum evaporator. The specimen was observed and photographed with J. M. S. -2 type S. E. Microscope.

Result

1 week after transplantation.

The junction between the host cartilage and the graft is seen as the defect. There is no bridging between the host and the graft at this period.

The surface of the graft is quite undulating and is composed of tightly woven fiber bundles of various size, 5～7μ in thickness, presumably corresponding to the bundle of collagen fibrils. (Fig. 2)

The fiber consists of the numerous finer fibrils, 0.1～0.3μ in thickness. They are densely interwoven into a network.

4 weeks after transplantation.

The fiber bundles ca. 5μ in diameter start to bridge between the graft and the host cartilage.

The fiber bundle consists of the numerous fine fibrils which look like collagen fiber of ca. 0.1～0.3μ in diameter. (Fig. 3)

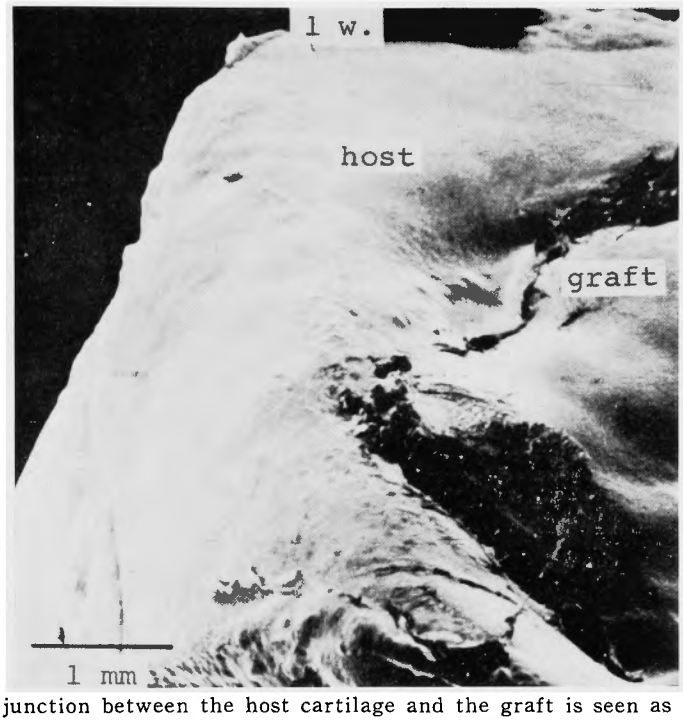

Fig. 2 The junction between the host cartilage and the graft is seen as the defect. The surface of the graft is quite undulating and is composed of tightly woven fiber bundles. 1 week after transplantation.

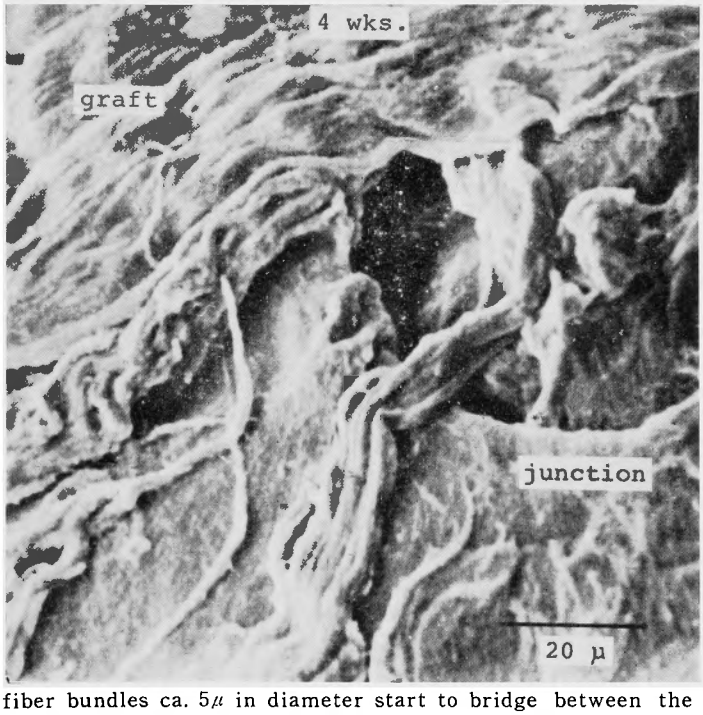

Fig. 3 The fiber bundles ca. 5μ in diameter start to bridge between the graft and the host cartilage. The fiber bundle consists of the numerous fine fibrils. 4 weeks after transplantation.

According to the histological examination, the junction is covered partly with the thin connective tissue layer, and moderate round cell infiltration is seen at the base of the graft. (Fig. 4)

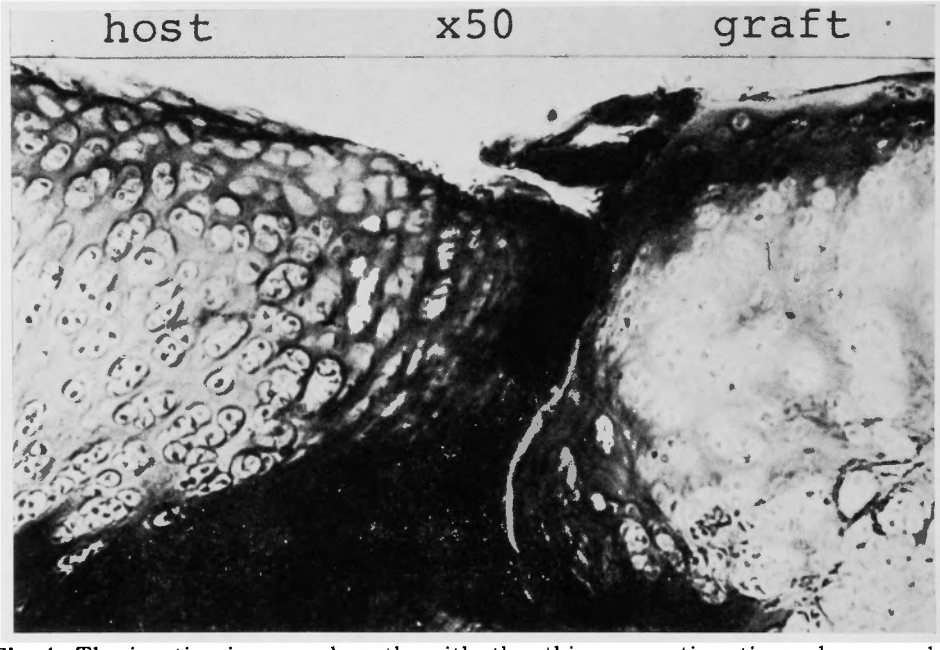

Fig. 4 The junction is covered partly with the thin connective tissue layer, and moderate round cell infiltration is seen at the base of the graft.
4 weeks after transplantation. Alcian blue staining. x 50.

12 weeks after transplantation

The junction is covered with the thin connective tissue layer, extending from the both edges of the cartilage. They overlap each other. Especially, the development of the fiber bundles is predominant from the host side. It appears that the regenerating tissue from the host tissue is going to cover the degenerating graft surfaces. (Fig. 5)

Observing the cleavage at the junction, which was produced on drying procedure, the graft consists of numerous, thin superficial layers, forming the lamellar structure into the deep tissue, where fibrils are tightly packed together in a radial manner at the deeper zone. (Fig. 6)

At the junction, the surface is rough, comparing to the graft and host surface, with irregularly running collagen fibers, various shaped cells and their processes. The bundles appear to be nodular and swollen. (Fig. 7)

24 weeks after transplantation

Histological examination reveals that cartilage tissue appears degenerating at the edge of the graft cartilage, also at the edge of the host cartilage.

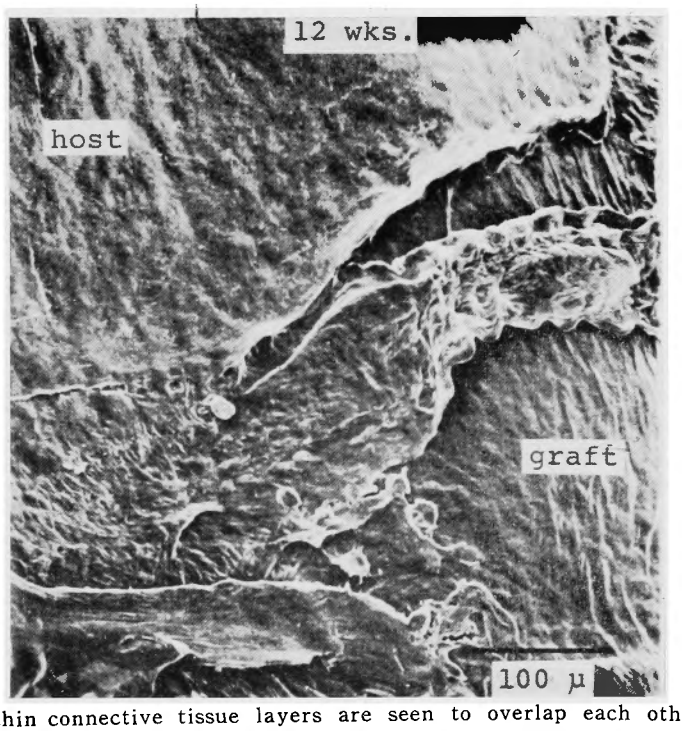

Fig. 5 The thin connective tissue layers are seen to overlap each other, at the junction. 12 weeks after transplantation.

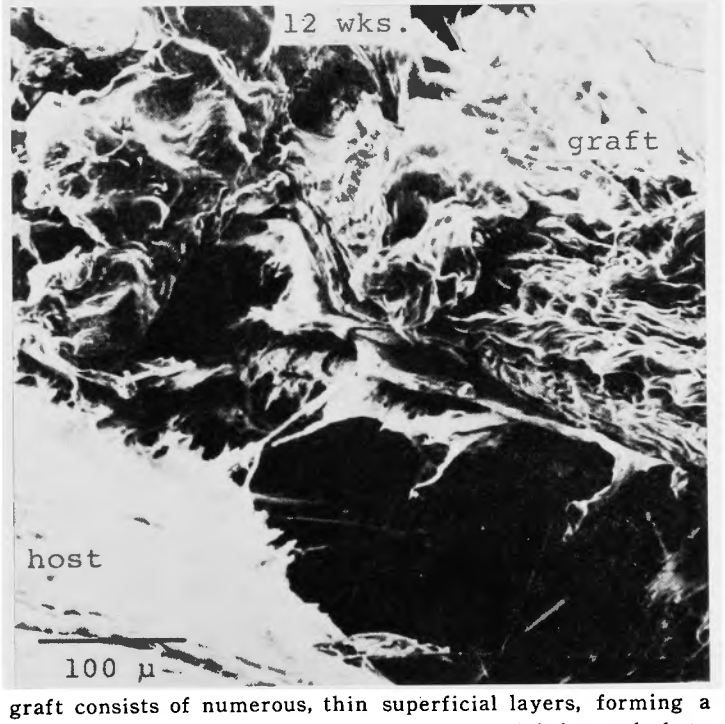

Fig. 6 The graft consists of numerous, thin superficial layers, forming a lamellar structure into the deep tissue, where fibrils are tightly packed together in a radial manner at the deeper zone. At the cleavage in the junction, produced incidentally by drying procedure. 12 weeks after transplantation.

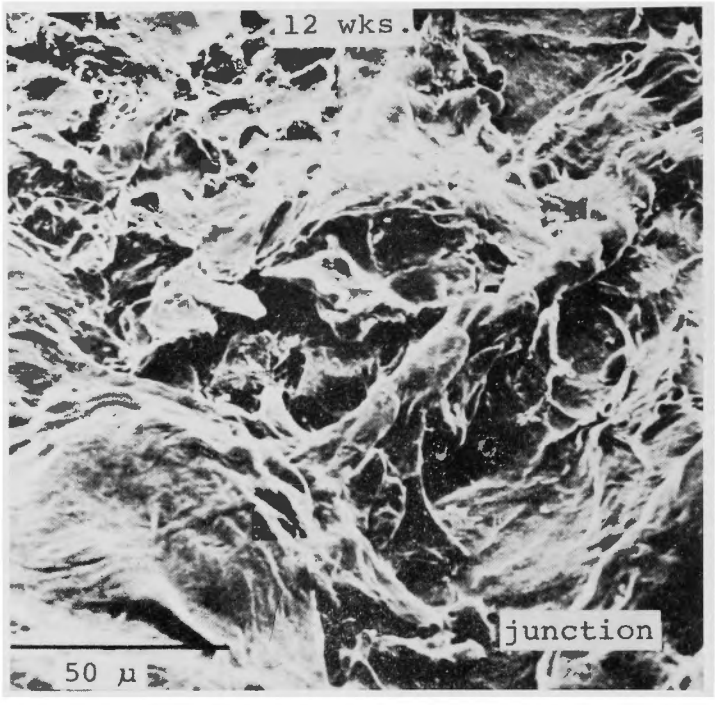

Fig. 7 Irregularly running collagen fibers, various shaped cells and their processes are obserbed at the junction. 12weeks after transplantation.

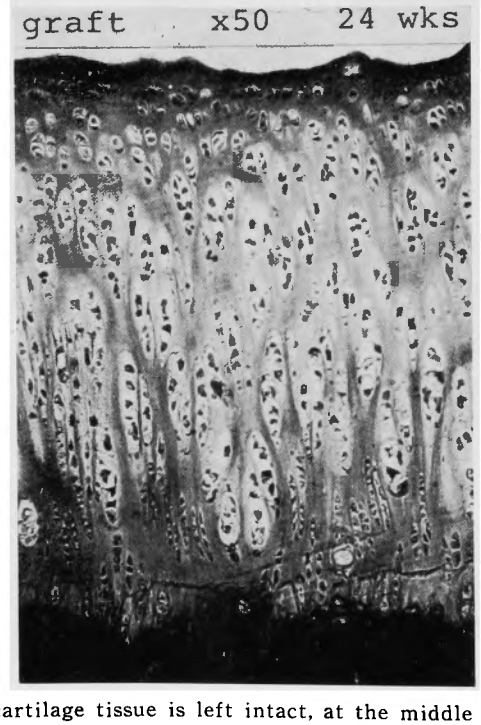

Fig. 8 Hyaline cartilage tissue is left intact, at the middle of the graft. 24 weeks after transplantation. Alcian blue staining. × 50.

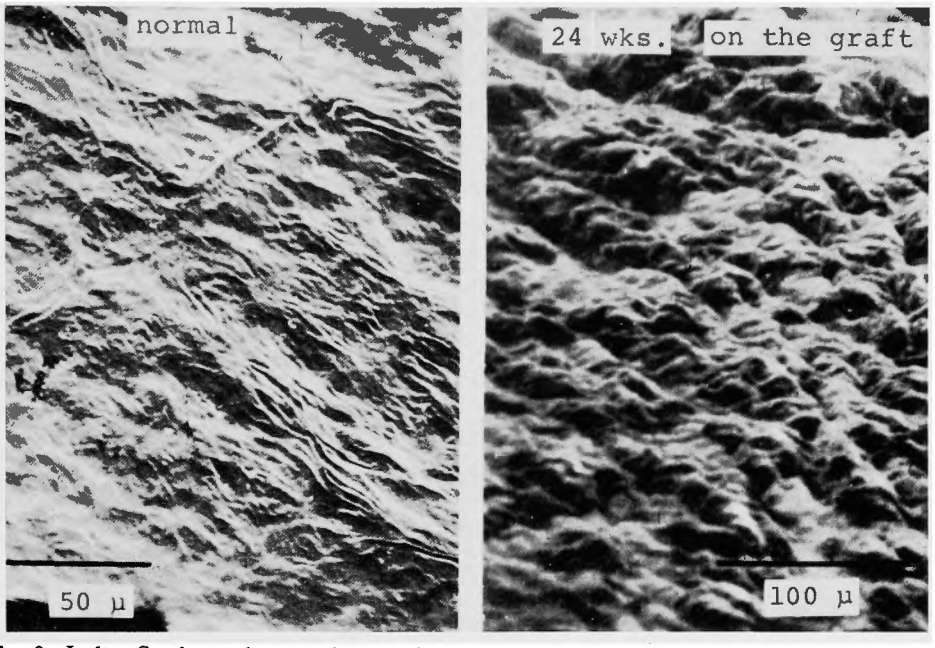

Fig. 9 Left : Surface of normal articular cartilage. Right Surface at the middle of the graft. The surface is relatively roughened and quite undulating with tightly woven fiber bundle. 24 weeks after transplantation.

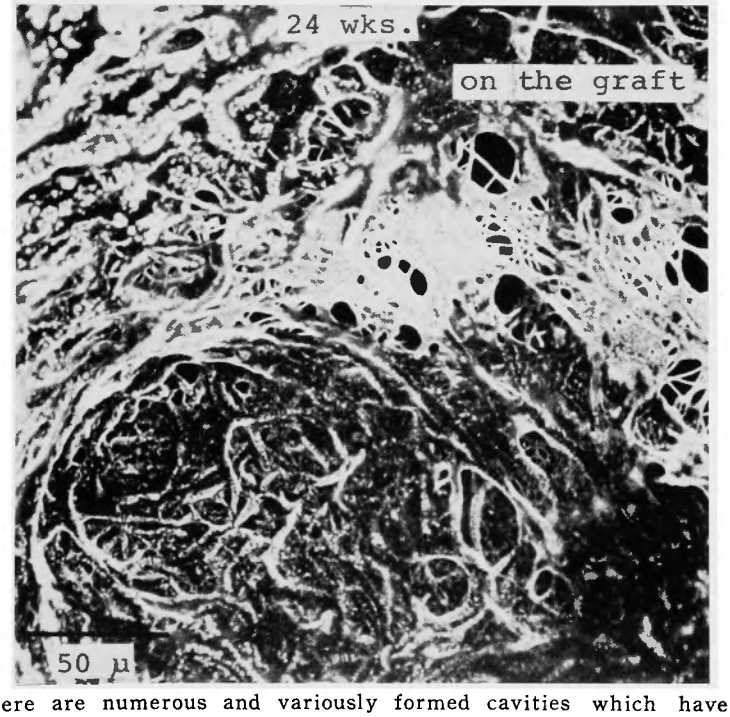

Fig. 10 There are numerous and variously formed cavities which have deeply eroded the cartilage substance, undermining the fibrillar net, in the case in which the surface of the graft has an adhesion with the surrounding synovial tissue. 24 weeks after transplantation.

At the middle of the graft, hyaline cartilage tissue is left intact with no obvious finding of degeneration. (Fig. 8)

The surface is relatively roughened and quite undulating with tightly woven fiber bundles of various size, at the middle graft. (Fig. 9)

In the case in which the graft adheres the surrounding synovial tissue, the cartilage surface macroscopically reveals pannus formation which originates from the surrounding synovial tissues. S. E. M. examination reveals that there are numerous and variously formed cavities which have deeply eroded the cartilage substance, undermining the fibrillar net. The cavities appear to correspond to the empty lacunae of the cartilage tissue. (Fig. 10)

Discussion

A number of investigators have reported their observation of articular cartilage in the scanning electron microscope.[2,5,10,11,14,16,17.] McCall was the first to demonstrate differences in surface appearence of normal and pathological cartilage.

McCall[12] described very large unbanded fibrils in human articular cartilage. In the superficial zone, fibrils were tightly packed in bundle which lay parallel to the surface. In the middle zone, the fibrils were random, while the deeper zone contained fibrils tightly packed together in a radial manner.

Fuller[8] noticed that partial thickness defects in the articular cartilage of immature rabbits failed to show a significant repair reaction capable of filling the defect. At the end of 6 months, there was some remodelling of the surface of the defect, which was covered by fine fibers oriented parallel to the surface.

According to our experiment, the junction was covered with the thin connective tissue layers, extended from both graft and host edges of the cartilage. The development of the fiber bundles was predominant from the host tissue.

Histological examination revealed that cartilage tissue appeared degenerating at the edges of the graft and host cartilage, at 24 weeks after transplantation. At this time, hyaline cartilage was left intact without any findings of degeneration at the middle portion of the graft.

Summary

Behavior and fate of the grafted articular cartilage was studied in 50 adult rabbits, using scanning electron microscope and histological staining method.

The junction between the host cartilage and the grafted cartilage started to be covered with thin connective tissue layers which was extended from both edges of the cartilage, at 4th week after transplantation. The cartilage tissue appeared degenerating at the periphery of the grafted cartilage, also at the edge of the host cartilage, at 24th week after transplantation Hyaline cartilage was left intact without any finding of degeneration at the middle portion of the graft.

References

1) Allbrook, D., Kirkaldy-Willis, W. H. : The restoration of articular surfaces after joint excision. J. B. J. S., **40**-B **4** : 742-764, 1958.
2) Barnett, C. H., Cochrane, W. & Palfrey, A. J. : Age changes in articular cartilage of rabbits, Ann. rheum. Dis. **22** : 389-400, 1963.
3) Campbell, C. J., Ishida, H. Takahashi, H. & Kelly, F. : The Transplantation of articular cartilage. J. B. J. S., **45**-A, **8** : 1579-1592, 1963.
4) Chesterman, P. J. & Smith, A. U. : Homotransplantation of articulars cartilage and isolated chondrocytes. J. B. J. S., **50**-**B**.(1) : 184-197, 1968.
5) Clarke, I. C. : Articular cartilage. J. B. J. S. **53**-**B**,(**4**) : 732-750, 1971.
6) DePalma, A. F., Tsaltas, T. T., & Mauler, G. G. : Viability of osteochondral grafts as determined by uptake of S35. J. B. J. S., **45**-**A**, (8) : 1565-1578, 1963.
7) Dupertuis, S. M. . Actual growth of young cartilage transplants in rabbits. Archives of Surgery, **43** : 32, 1941.
8) Fuller, J. A., Ghardially, F. N. : Ultrastractural observations on surgically produced partial thickness defects in articular cartilage, Clinical orthopedics & related research, **86** 193-205, 1972.
9) Green, W. T. Jr. : Behavior of articular chondrocytes in cell culture. Clinical orthopedics & related research, **75** : 248-260, 1971.
10) Hirohata, K. & Ishikawa **0.** : On the treatment of osteoarthritis of the hip. (in Japanese) Japanese Clinical Orthopedics, **5**(6): 1424-1436, 1970.
11) Inoue, H., Kodama, T. & Fujita, T.: Seanning electron microscopy of normal and rheumatoid articular cartilage. Arch, histol. jap, **30** (5) : 425-435, 1969.
12) McCall, J. G., : Scanning electron microscopy of articular surfaces. Lancet, **2** : 1194, 1968.
13) McKibbin, B. : Immature joint cartilage and the homograft reaction. J. B. J. S., **53B**. (1) : 123-135, 1971.
14) Meachin, G., Ghadially, F. N., & Collins, D. H. : Regressive changes in the superficial layer of human articular cartilage. Ann. rheum. Dis., **24**: 23-30, 1965.
15) Prudden, T. M. : Experimental studies on the transplantation of cartilage. Americal Journal of Medical Sciences, **82** : 360, 1881.
16) Redler, I. Zimmy, M. : Scanning electron microscopy of normal and abnormal articular cartilage and synovium. J. B. J. S., **52**-**A**, (7) : 1395-1404, 1970.
17) Walker, P. S., Sikorski, J. Dowson, D., Longfield, M. D., Wright, V., & Buckley, T. : Behaviors of synovial fluid on surfaces of articular cartilage (A scanning electron microscope study). Ann. rheum. Dis., **28** : 1-14, 1969.

和文抄録

関節軟骨移植の実験的研究

——走査電顕ならびに組織学的研究——

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時岡孝夫

関節軟骨の移植は古く1881年 Prudden らによって始められて以来，種々の報告がある．

血管支配のない，すなわち avascular protein としての性質をもつ軟骨は他の臓器と比較して拒絶反応が少ないと言われている．

我々は成熟家兎を用いて軟骨同種移植を行ない，走査電子顕微鏡的観察を中心として，その生着状態について検索を行ない，以下の結果を得た．

(1) 移植後1週目においては移植片と host と結合はみられない．移植後4週目になると移植片の辺縁には細胞浸潤が認められるようになるとともに，接合部の表面は膠原線維束などの結合組織によって被覆されはじめ host との結合が認められるようになる．

(2) 移植後24週になると硝子様軟骨組織は移植片の中央部に残存している．この部の表面を観察すると結合組織の線維束によって生じる隆起の波状構造が認められ，その波形は，やや粗で不規則であり波高も高いが，正常軟骨部に近い平坦な表面を呈するようになる．